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World Intellectual Property Organization (WIPO) - Geneva, Switzerland
Organisation Mondiale de la Propriété Intellectuelle (OMPI) - Genève, Suisse

1335262

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UNITED STATES DEPARTMENT OF COMMERCE

United States Patent and Trademark Office

*June 17, 2005*

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**APPLICATION NUMBER:** ***60/570,067***
**FILING DATE:** ***May 12, 2004***
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UNITED STATES PATENT AND TRADEMARK OFFICE
DEPARTMENT OF COMMERCE

Certified by

Jon W. Dudas

Under Secretary of Commerce
for Intellectual Property
and Director of the United States
Patent and Trademark Office

Attorney Docket No. GRA26 026

# IN THE UNITED STATES PATENT AND TRADEMARK OFFICE



Sir:

Transmitted herewith for filing is the PROVISIONAL APPLICATION

for a patent of Inventor(s):

ANDREW BECK and JOSEPH P. KENNEDY, JR.

Title: SYSTEM AND METHOD FOR DETECTING A MOBILE STATION OPERATING THROUGH A REPEATER

Enclosed are:

[X] A Cover Page and Three (3) pages of specification.

[X] A check in the amount of $160.00 to cover the filing fee.

The Commissioner is hereby authorized to charge payment of any additional fees associated with this communication or to credit any overpayment to Deposit Account No. 04-1679. A duplicate of this sheet is enclosed.

Respectfully submitted,

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# SYSTEM AND METHOD FOR DETECTING A MOBILE STATION OPERATING THROUGH A REPEATER

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Invention Disclosure: Detection of a Mobile Station Operating through a Repeater

This invention discloses a method to determine if a mobile station operating in a wireless network utilizing a repeater is communicating with the base station through the repeater or through other means. Incorporated as prior art are descriptions of wireless networks supporting voice and data traffic; repeaters used to "repeat" the RF signal to enhance range, coverage or service quality; and mobile appliances attached to the wireless network and used as terminal devices for voice or data interfacing. A typical example of a wireless appliance is a cell phone.

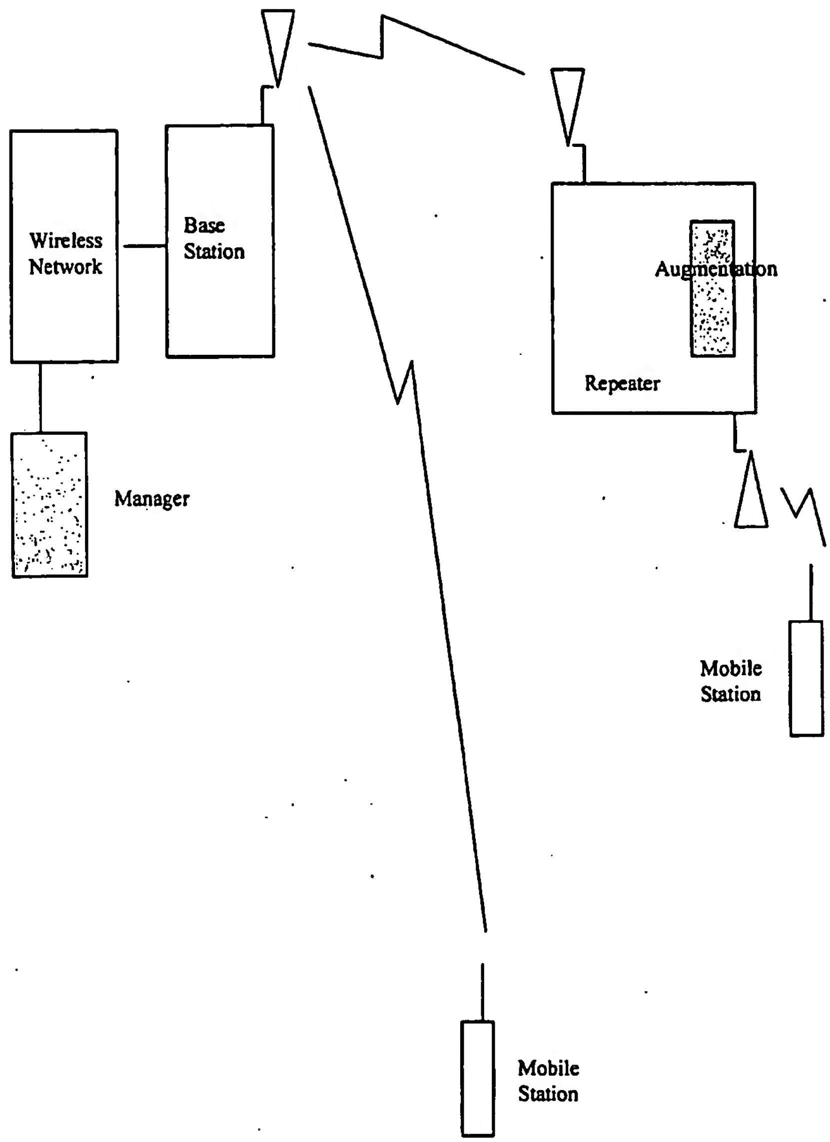
A wireless operator may want to know how a particular mobile appliance is being served in an area to understand how his wireless network is operating, or to size and provision repeaters or other network equipment in an area.

Repeaters are generally deployed in a wireless network in such a way that the network does not know they are present. For example, a repeater may be placed in a building to provide service within the structure. Here, a wireless base station may have a sector that is designed to serve the building, but because of propagation effects, a mobile appliance operating in the building does not have reliable service. A repeater can be added to the building to boost the forward and reverse link signals to an acceptable level. The serving sector does not "know" that the repeater is present, it sends and receives signals in the same way whether a repeater is present or not present. Likewise, the repeater is not aware of what mobile transmissions are being carried through it, or directly to the base station sector.

The base station serving sector may serve mobiles either through the repeater, or directly. The repeater, or set of repeaters, in the sector footprint may be located close to, or far from the base station. The repeaters can provide coverage over a large area or very small targeted area. The repeaters can operate with different power boosting levels and delays. Thus the serving sector has no way of determining the way in which mobiles are served.

Generally, a repeater is installed such that one antenna is placed in a position to have clear view of the base station serving sector antennas (designated the repeater to base station antenna), and one antenna (or set of antennas) are placed to have good coverage for the mobile appliances to be served (designated the repeater to mobile antenna). Electronics are placed between the antennas to amplify and filter the signals.

This invention uses an augmentation to the repeater to determine which mobile appliances are operating through the antenna (see figure).




The augmentation is composed of a scanning receiver and a mechanism for interfacing to a data service used to communicate with the Manager. The augmentation may be housed in the repeater and is connected to the repeater- to- mobile antenna of the repeater. The augmentation scans the reverse link channels where a mobile appliance might transmit and measures energy and/or signal characteristics. These channels can be represented as RF frequencies, time slots, spreading codes or combination thereof. These measurements are made to determine if a mobile appliance is operating in the proximity of the repeater antenna. If signal strength and/or quality are high (or within a certain band), then it is assumed that the mobile is operating through the repeater. The measurements and/or channel indicators for a mobile appliance determined to be operating through the repeater are transmitted to the manager. The measurements may be tested at the augmentation or at the manager. The measurements can be tested based on signal strength, particular band of received power, or signal characteristics. The band of received power may be mapped to the power management algorithms that a particular air interface will employ to control the power level of a mobile

appliance. Decoding of certain signal characteristics (for example, presence of sync codes) can indicate sufficient power level to measure characteristics, and positive indication that the signal energy on that channel is from the a device connected to the wireless network of interest.

The data service is most conveniently a data transport mechanism supported by the wireless network of interest. For example, in a GSM network that supports GPRS, the measurement data from the augmentation or channel results could be transferred to the manager using this data service. SMS services available in TDMA and GSM are also candidates. Wireless connections (e.g. T1, modem, frame relay) are also an option. The manager serves as the control and management device for the augmentation(s), and as an interface point for access to the list of mobile appliances operating through certain repeaters. The manager can have data files indicating where repeaters with augmentations are located in the network, and through connections to other wireless network entities, translate channel information to mobile identity information. In a GSM network, this might consist of translating a traffic channel assignment to a TMSI or MSISDN through access to network data at the BSC or HLR/VLR.

Implementation of the augmentation and manager in this fashion is convenient and cost effective. The functions incorporated into the augmentation for the most part reside in the building blocks found in today's commercial handsets. Thus, the augmentation could be added to a repeater for a fraction of the recurring cost of handset components. The manager could be conceived as a new software component executing on an existing computing device in a wireless network, shared with other functions associated with network entities to which it would be convenient to interface.

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Certified by

Jon W. Dudas

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Attorney Docket No. GRA26 029



# IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Sir:

Transmitted herewith for filing is the PROVISIONAL APPLICATION

for a patent of Inventor(s):

MARTIN ALLES, JOSEPH P. KENNEDY, JR., and JOHN CARLSON

Title: SYSTEM AND METHOD FOR IDENTIFYING THE PATH OR DEVICES ON THE PATH OF A COMMUNICATION SIGNAL USING (1+r(t)) AMPLITUDE MODULATION

Enclosed are:

[X] A Cover Page and Three (3) pages of specification.

[X] A check in the amount of $160.00 to cover the filing fee.

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Respectfully submitted,

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Dated: May 12, 2004

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# SYSTEM AND METHOD FOR IDENTIFYING THE PATH OR DEVICES ON THE PATH OF A COMMUNICATION SIGNAL USING (l+r(t)) AMPLITUDE MODULATION

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Repeater Watermarking using (1+r(t)) type Amplitude Modulation

## 1.0 - Engineering concepts for watermark implementation at a repeater

Introduction:

This proposal is to address the issue of repeater identification via the signal insertion of a signal dependent co-channel signal in active channels. This co-channel signal is generated by applying a specific form of Amplitude Modulation (AM) to the entire repeated signal bandwidth, and serves as a watermark that identifies a mobile using a particular repeater station. The magnitude of the co-channel signal as well as any adjacent channel interference caused by the AM process can be controlled in magnitude. When no signal is present, the AM process generates a signal buried deep within the noise. When a signal is present, the co-channel signal can be used to uniquely identify the repeater. The latter signal may also be buried in the noise by appropriate engineering.

Description of operations needed at the repeater:

The wideband signal w(t) constituting the signal to be repeated at the repeater is AM modulated at the repeater using a narrowband signal of the form (1+r(t)). The AM modulated signal is then subject to any pre-existing scheme of repetition used at that repeater (generally expressed as a delay on the signal followed by an amplification).

The mathematical effect of this form of modulation is to generate a co-channel signal w(t)r(t) in the repeater bandwidth. The "1" in the term "(1+r(t))" simply replicates the primary signal (the mobile signal). Since AM modulation is equivalent to multiplication, the modulation can also be viewed as multiplication of w(t) by the function (1+r(t)). Figure 1 illustrates the method of implementation where the operations are performed on a digitized signal at the repeater. The digitized signal represents the entire bandwidth operated on by the repeater.

To illustrate the concept further, consider a particular narrowband channel. In that channel, if there was an active mobile call using signal s(t) in progress, the co-channel signal generated by the AM process will be of the form s(t)r(t). If the channel were inactive, the co-channel signal will be of the form n(t)r(t) where n(t) is noise. By suitably controlling the norm (or average amplitude) of r(t), the magnitude of the co-channel component can be maintained at a much reduced power level with respect to the primary mobile signal s(t). Further, any spectral spillage into adjacent bins can be reduced below the noise power level in those bins by suitably manipulating the amplitude of r(t). In fact, by controlling the amplitude of r(t), we can make both the co-channel signal component and the adjacent channel interference as large as or as small as desired. The amplitude control is determined based on the relative power desired between the primary signal s(t) and the co-channel component. After the proper determination is made, this amplitude is fixed at the repeater during operation.

If the signal at the repeater is processed digitally, the digital samples representing the repeater bandwidth are multiplied by the waveform r(t) and added back to the signal. The amplitude of the waveform r(t) (assumed constant modulus or nearly so) then automatically determines the magnitude/power of the watermark signal. Thus, by controlling the amplitude of the signal r(t) in the digital operations at the repeater, the inserted co-channel component defining the watermark can be power controlled. It is expected that this amplitude will be pre-computed and implemented so that the co-channel watermark signal is buried in the noise.

Thus, for example in an active cellular channel, the introduced repeater identification signal can be at a power level 20dB or lower than the primary signal, whereas in an inactive channel, the repeater identification signal will be 20dB or lower than the pre-existing noise in that channel. In every channel, the corresponding repeater signal is at a power level 20dB or lower than the pre-existing signal level in that channel. The 20dB value is chosen simply to quantify the concept and any other dB number can be picked with equal applicability, and implemented via the specified amplitude used for r(t) in the digital signal processor.

For a given mobile signal s(t), it is apparent that the signal r(t) is what distinguishes the particular repeater. Thus each repeater has a unique narrowband waveform r(t).

The collection of such waveforms r(t) over a set of repeaters, denoted S, may be drawn from sets of waveforms with specific properties. For example the set S may be orthogonal, quasi-orthogonal, or shift orthogonal. The properties of the waveforms r(t) used to generate the set S will, among other things, depend on the number of repeaters implemented in a cellular system cell or sector. A good set that we have used in extensive simulations is the set of 26 waveforms in a Golay-Hadamard codebook, derived from complementary Golay sequences.

The repeaters may either apply their identifying signals synchronously or asynchronously. A synchronous approach would require the repeaters to operate in unison with an extraneous clock but would provide greater discrimination of the repeater at the receiver. For ease of operation, it is expected that the identifying signal will be applied asynchronously, so that each repeater station will operate independent of all other stations, and independent of any extraneous control.

The repeaters should also apply their identifying signals in a repetitive loop so that the waveforms r(t) cycle over and over again (repeat). Thus the signal r(t) can be envisioned as the output of a cyclic shift register. The bandwidth of these waveforms will typically be of the order of 30kHz.

In Figure 1, $w_k$ is the digitized repeater input, $r_k$ is the repeater identification waveform and $w_k$' is the repeater output sample.

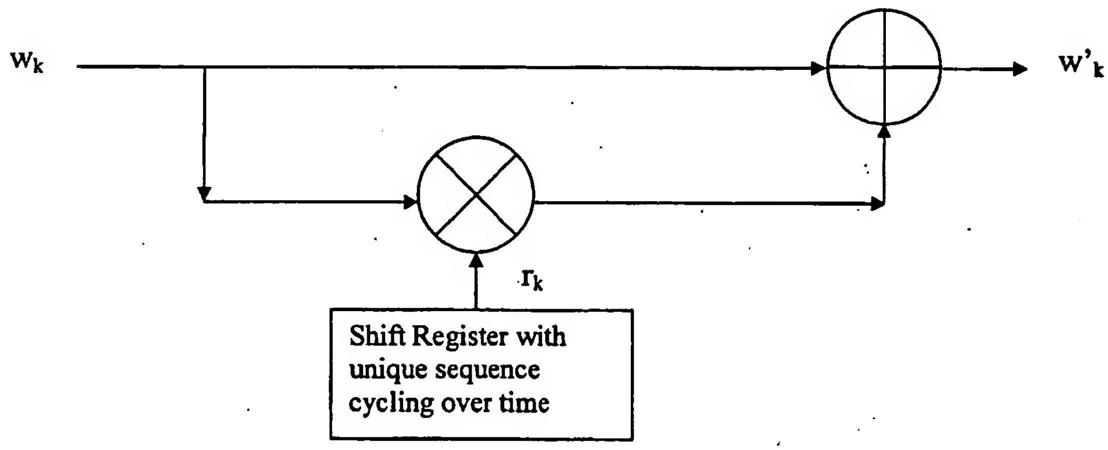


**Figure 1: Digital Operations for watermark implementation**

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13281 U.S.PTO
051204

Attorney Docket No. GRA26 028

22154 U.S. PTO
60/570082
051204

# IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Sir:

Transmitted herewith for filing is the PROVISIONAL APPLICATION

for a patent of Inventor(s):

JOSEPH P. KENNEDY, JR., MARTIN ALLES, and JOHN CARLSON

Title: SYSTEM AND METHOD FOR IDENTIFYING THE PATH OR DEVICES ON THE PATH OF A COMMUNICATION SIGNAL

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Mark C. Comtois

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# SYSTEM AND METHOD FOR IDENTIFYING THE PATH OR DEVICES ON THE PATH OF A COMMUNICATION SIGNAL

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**An invention whose application is to the identification of the path (or devices on the path) of a communication signal**

## 1.0 Context

(a) This application relates to the communication of information over a communication medium, wireless or otherwise.
(b) A communication system is the entirety of a transmitter, a communication path or link/channel, devices along the path through which the signal passes and a receiver.
(c) The communication link/path introduces distortions on signals whose origins may be thermal noise or other interfering signals.
(d) Primary information is the information content for which the communication system was intended. For example, in a cellular communication system, the primary information may be speech. A Primary receiver is one whose design is motivated for the sole purpose of extracting primary information.
(e) The Primary signal is that signal emanating from the transmitter and decoded by the primary receiver which contains the Primary information.
(f) Secondary information is information encoded onto/over/into the Primary signal in such a manner that it is:
  (1) Transparent to the Primary receiver. The operation of the Primary receiver remains *identical* in the presence or absence of the secondary information.
  (2) Recoverable only by a Secondary receiver which has access to both the input *and* the output of the Primary receiver.
  (3) Inserted as a Secondary signal or signals at one or more devices in the path of the primary signal as it traverses from the transmitter to the Primary receiver.

## 2.0 Injection of the Secondary signal

(a) The Secondary signal is formed as a function of *both* the device through which the primary signal passes *and* the Primary signal. Mathematically, if $w(t)$ represents the Secondary signal injected at device $i$, $w(t)=f(i, s(t))$. The function $f(.)$ represents the mapping and $s(t)$ the Primary signal.
(b) The Secondary signal is modified such that it appears to be a component of the distortion of whatever nature, experienced on the channel/link. As one example, if the distortion is additive noise, the modification is to scale the Secondary signal so that it is below the power level of the noise. The notation $w(t)$ will also denote the modified signal.
(c) The Secondary signal is transmitted within the same channel as the Primary signal. By channel we mean the same time period and bandwidth or any other generic Primary signal characterization.
(d) The function $f(.)$ generating the Secondary signal has the property that given the output of the Primary receiver, the function can be inverted so that the particular device $i$ may be identified.

### 3.0 Recovery of the Secondary signal

(a) A Secondary receiver has access to both the input *and* the output of the Primary receiver.
(b) The Secondary receiver removes the primary signal (reconstructed if need be from the output of the Primary receiver) from the input signal at the Primary receiver, thus exposing the Secondary signal.
(c) The Secondary receiver implements the inverting function given by $[\,i\,]=g(w(t),s(t))$, where $g(.)$ inverts $f(.)$.
(d) The Secondary receiver identifies the device associated with the determination $i$.
(e) Multiple devices in the path may be identified using appropriate functions $g(.)$ that represent the needed inversions for each function $f(.)$ each of which may have been operating at different device locations along the Primary signal path.